VIII. *Some experiments and observations on the colours used in painting by the Ancients.* *By Sir* Humphry Davy, *LL. D. F.R.S.*

Read February 23, 1815.

I. *Introduction.*

THE importance the Greeks attached to pictures, the estimation in which their great painters were held, the high prices paid for their most celebrated productions, and the emulation existing between different states with regard to the possession of them, prove that painting was one of the arts most cultivated in ancient Greece; the mutilated remains of the Greek statues, notwithstanding the efforts of modern artists during three centuries of civilization, are still contemplated as the models of perfection in sculpture, and we have no reason for supposing an inferior degree of excellence in the sister art, amongst a people to whom genius and taste were a kind of birthright, and who possessed a perception, which seemed almost instinctive, of the dignified, the beautiful, and the sublime.

The works of the great masters of Greece are unfortunately entirely lost. They disappeared from their native country during the wars waged by the Romans with the successors of Alexander, and the later Greek republics; and were destroyed either by accident, by time, or by barbarian conquerors at the period of the decline and fall of the Roman Empire.

The subjects of many of these pictures are described in

ancient authors, and some idea of the manner and style of the Greek artists may be gained from the designs on the vases, improperly called Etruscan, which were executed by artists of Magna Græcia, and many of which are probably copies from celebrated works: and some faint notion of their execution and colouring may be gained from the paintings in fresco found at Rome, Herculaneum, and Pompeii.

These paintings, it is true, are not properly Greek, yet whatever may be said of the early existence of painting in Italy as a native art, we are certain that at the period when Rome was the metropolis of the world, the fine arts were cultivated in that city exclusively by Greek artists, or by artists of the Greek schools. By comparing the descriptions of VITRUVIUS* and PLINY with those of THEOPHRASTUS,† we learn that the same materials for colouring were employed at Rome and at Athens; and of thirty great painters that Pliny mentions whose works were known to the Romans, two only are expressly mentioned as born in Italy, and the rest were Greeks. Ornamental fresco painting was indeed generally exercised by inferior artists; and the designs on the walls of the houses of Herculaneum and Pompeii, towns of the third or fourth order, can hardly be supposed to offer fair specimens of excellence, even in this department of the art: but in Rome, in the time of her full glory, and in the ornaments of the imperial palace of the first Cæsars, all the resources of the distinguished artists of that age were probably employed. PLINY names CORNELIUS PINUS and ACCIUS PRISCUS as the two artists of the greatest merit in his own time, and states that they painted the Temple of Honour and Virtue,‡ "Imperatori

* De Architectura, Lib. vii. Cap. 5. † De Lapidibus.

‡ Plin. Nat. Hist. Lib. xxxv. Cap. 37.

Vespasiano Augusto restituenti," and it is not improbable, that these artists had a share in executing, or directing the execution of the paintings and ornaments in the baths of Titus; and at this period the works of Zeuxis, Parrhasius, Timanthes, Apelles, and Protagoras were exhibited in Rome, and must have guided the taste of the artists. The decorations of the baths were intended to be seen by torch light, and many of them at a considerable elevation, so that the colours were brilliant and the contrast strong; yet still these works are regarded by connoisseurs as performances of considerable excellence: the minor ornaments of them have led to the foundation of a style in painting which might with much more propriety be called Romanesque than Arabesque: and no greater eulogy can be bestowed upon them than the use to which they have been applied by the greatest painter of modern times, in his exquisite performances in the Vatican. In these and in other works of the same age, the effect of the ancient models is obvious; and the various copies and imitations that have been made of these remains of antiquity have transferred their spirit into modern art, and left little to be desired as to those results which the skill of the painter can command. There remains, however, another use to which they may be applied, that of making us acquainted with the *nature* and *chemical composition* of the colours used by the Greek and Roman artists. The works of THEOPHRASTUS, DIOSCORIDES, VITRUVIUS, and PLINY, contain descriptions of the substances used by the ancients as pigments; but hitherto, I believe, no experimental attempt has been made to identify them, or to imitate such of them as are peculiar.* In the

* In the 70th Volume of the Annales de Chimie, page 22, M. CHAPTAL has

following pages I shall have the honor of offering to the Society an investigation of this subject. My experiments have been made upon colours found in the baths of Titus, and the ruins called the baths of Livia, and in the remains of other palaces and baths of ancient Rome, and in the ruins of Pompeii. By the kindness of my friend, the celebrated CANOVA, who is charged with the care of the works connected with ancient art in Rome, I have been enabled to select, with my own hands, specimens of the different pigments that have been found in vases discovered in the excavations, lately made beneath the ruins of the palace of Titus, and to compare them with the colours fixed on the walls or detached in fragments of stucco: and Signor NELLI, the proprietor of the Nozze Aldobrandine, with great liberality permitted me to make such experiments upon the colours of this celebrated picture, as were necessary to determine their nature. When the preservation of a work of art was concerned, I made my researches upon mere atoms of the colour, taken from a place where the loss was imperceptible: and without having injured any of the precious remains of antiquity, I flatter myself, I shall be able to give some information not without interest to scientific men as well as to artists, and not wholly devoid of practical applications.

published a paper on seven colours found in a colour shop at Pompeii. Four of these he found to be natural colours, ochres, a specimen of Verona green, and one of pumice stone. Two of them were blues, which he considers as compounds of alumine and lime with oxide of copper, and the last a pale rose colour, which he regards as analogous to the lake formed by fixing the colouring matter of madder upon alumine. I shall again refer to the observations of M. CHAPTAL in the course of this paper. It will be found on perusal, that they do not supersede the enquiry mentioned in the text.

II. *Of the red colours of the Ancients.*

Amongst the substances found in a large earthen vase filled with mixtures of different colours with clay and chalk, found about two years ago in a chamber at that time opened in the baths of Titus, are three different kinds of red. One bright and approaching to orange, another dull red, a third a purplish red.* On exposing the bright red to the flame of alcohol, it became darker red, and on increasing the heat by a blowpipe, it fused into a mass having the appearance of litharge, and which was proved to be this substance by the action of sulphuric and muriatic acids. This colour is consequently minium, or the red oxide of lead.

On exposing the dull red to heat, it became black, but on cooling recovered its former tint. When heated in a glass tube it afforded no volatile matter condensible by cold but water. Acted on by muriatic acid, it rendered it yellow, and the acid, after being heated upon it, yielded an orange coloured precipitate to ammonia. When fused with hydrate of potassa, the colour rendered it yellow; and the mixture acted on by nitric acid afforded silica and orange oxide of iron. It is evident from these results that the dull red colour is an iron ochre.

The purplish red submitted to experiments, exhibited similar phenomena, and proved to be an ochre of a different tint.

In examining the fresco paintings in the baths of Titus, I found that these colours had been all of them used, the ochres particularly, in the shades of the figures, and the minium in the ornaments on the borders.

I found another red on the walls, of a tint different from

* Nearly of the same tint as prussiate of copper.

those in the vase and much brighter, and which had been employed in various apartments, and formed the basis of the colouring of the niche and other parts of the chamber in which the Laocoon is said to have been found. On scraping a little of this colour from the wall, and submitting it to chemical tests, it proved to be vermilion or cinnabar, and on heating it with iron filings, running quicksilver was procured from it.

I found the same colour on some fragments of ancient stucco in a vineyard near the pyramidal monument of CAIUS CESTIUS.

In the Nozze Aldobrandine, the reds are all ochres. I tried on these reds the action of acids, of alkalies, and of chlorine, but could discover no traces either of minium or vermilion in this picture.

Minium was known to the Greeks under the name of σανδαράχη,* and to the Romans under that of cerussa usta. It is said, by PLINY,† to have been discovered accidentally by means of a fire that took place at the Piræeus at Athens. Some ceruse which had been exposed to this fire was found converted into minium, and the process was artificially imitated: and he states that it was first used as a pigment by NICIAS.‡

Several red earths used in painting are described by THEOPHRASTUS, VITRUVIUS,§ and PLINY. The Sinopian earth, the Armenian earth, and the African ochre, which had its red colour produced by calcination.

Cinnabar or vermilion was called by the Greeks κιννάβαρι,‖ and by the Romans minium. It is said by THEOPHRASTUS¶ to have been discovered by CALLIAS, an Athenian, ninety years before PRAXIBULUS, and in the 349th year of Rome, and was

* Dioscorides, Lib. v. 122.

‡ Pliny, Lib. xxxv. Cap. 20. Dioscorides, Lib. v. Cap. 109.

† Lib. xxxv. Cap. 20.

§ De Architectura, Lib. vii. Cap. 7.

¶ De Lapid. Cap. 104.

prepared by washing the ores of quicksilver. According to PLINY,* who quotes VERRIUS, it was a colour held in great esteem in Rome at the time of the Republic; on great festivals it was used for painting the face of Jupiter Capitolinus, and likewise for colouring the body of the Victor in the triumphal processions, " sic Camillum triumphasse."† PLINY mentions that even in his time vermilion was always placed at triumphal feasts amongst the precious ointments; and that the first occupation of new censors of the Capitol was to fill the place of vermilion painter to Jupiter.

Vermilion was always a very dear colour amongst the Romans; and we are informed by PLINY that to prevent the price from being excessive, it was fixed by the government. The circumstance of the chambers in the baths of Titus being covered with it, affords proof in favour of their being intended for imperial use; and we are expressly informed by the author I have just quoted, that the Laocoon, in his time, was in the palace of Titus:‡ and the taste of the ancients in selecting a colour to give full effect to their master pieces of sculpture was similar to that of a late celebrated English connoisseur.

PLINY describes a second or inferior sort of vermilion formed by calcining stone found in veins of lead. It is evident, that this substance was the same as our minium, and the Roman cerussa usta, and the stones alluded to by PLINY must have been carbonate of lead: and he states distinctly, that it is a substance which becomes red only when burnt.

* Lib. xxxiii. Cap. 36. Nunc inter pigmenta magnæ auctoritatis, et quondam apud Romanos non solum maximæ, sed etiam sacræ. † Ibid.

‡ Lib. xxxvi. Cap. 4. Sicut in Laocoonte, qui est in Titi Imperatoris domo, opus omnibus et picturæ et statuariæ artis præponendum.

III. *Of the yellows of the ancients.*

A large earthen pot found in one of the chambers of the baths of Titus contains a quantity of a *yellow paint*, which, submitted to chemical examination, proved to be a mixture of yellow ochre with chalk or carbonate of lime.

This colour is used in considerable quantities in different parts of the baths; but principally in the least ornamented chambers, and in those which were probably intended for the use of the domestics. In the vase to which I alluded in the last section, I found three different yellows; two of them proved to be yellow ochres mixed with different quantities of chalk, and the third a yellow ochre mixed with red oxide of lead, or minium.

The ancients procured their yellow ochre* from different parts of the world, but the most esteemed, as we are informed by PLINY, was the Athenian ochre; and it is stated by VITRUVIUS, that in his time the mine which produced this substance was no longer worked.

The ancients had two other colours which were orange or yellow; the auripigmentum, or ἀρσενικον, said to approach to gold in its colour, and which is described by VITRUVIUS† as found native in Pontus, and which is evidently sulphuret of arsenic; and a *pale* sandarach, said by PLINY to have been found in gold and silver mines, and which was imitated at Rome by a partial calcination of ceruse, and which must have been massicot, or the yellow oxide of lead mixed with minium. That there was a colour called by the Romans sandarach, different from pure minium, is evident from what

* ὤχρα, Theophrastus de Lapidibus. † Vitruvius, Lib. vii.

PLINY says, namely, that the palest kind of orpiment resembles sandarach, and from the line of NAEVIUS, one of the most ancient Latin poets, " Merula sandaracino ore:" so that this colour must have been a bright yellow similar to that of the beak of the blackbird.* DIOSCORIDES describes the best σανδαράχη as approaching in colour to vermilion,† and the Greeks probably always applied this term to minium; but the Romans seem to have used it in a different sense; and some confusion was natural when different colours were prepared from the same substance by different degrees of calcination.

I have not detected the use of orpiment in any of the ancient fresco paintings; but a deep yellow approaching to orange, which covered a piece of stucco in the ruins near the monument of CAIUS CESTIUS, proved to be oxide of lead, and consisted of massicot mixed with minium. It is probable, that the ancients used many colours from lead of different tints between the usta of PLINY, which was our minium, and imperfectly decomposed ceruse, or pale massicot.

The yellows in the Aldobrandini picture are all ochres. I examined the colours in a very spirited picture, on the wall of one of the houses at Pompeii, of a lion and a man, they all proved to be red and yellow ochres.

IV. *Of the blue colours of the Ancients.*

Different shades of blue are used in the different apartments of the baths of Titus, and several very fine blues exist in the mixtures of colours to which I have referred in the last two sections.

These blues are pale or darker, according as they contain

* Histoire de la Peinture ancienne, page 199. † Lib. v. 122.

larger or smaller quantities of carbonate of lime, but when this carbonate of lime is dissolved by acids, they present the same body colour, a very fine blue powder similar to the best smalt or to ultramarine, rough to the touch, and which does not lose its colour by being heated to redness; but which becomes agglutinated and semifused at a white heat.

This blue I found was very little acted on by acids. Nitro-muriatic acid by being long boiled upon it gained, however, a slight tint of yellow, and afforded proofs of the presence of oxide of copper.

A quantity of the colour was fused for half an hour with twice its weight of hydrate of potassa; the mass which was bluish green was treated by muriatic acid in the manner usually employed for the analysis of siliceous stones, when it afforded a quantity of silica equal to more than $\frac{3}{5}$ of its weight. The colouring matter readily dissolved in solution of ammonia, to which it gave a bright blue tint, and it proved to be oxide of copper. The residuum afforded a considerable quantity of alumine, and a small quantity of lime.

Amongst some rubbish that had been collected in one of the chambers of the baths of Titus, I found several large lumps of a deep blue frit, which when powdered and mixed with chalk produced colours exactly the same as those used in the baths, and which when submitted to chemical tests were found to be the same in composition.

The minute quantity of lime found in this substance was not sufficient to account for its fusibility: it was therefore reasonable to expect the presence of a fixed alkali in it; and on fusing some of it with three times its weight of boracic acid, and treating the mass with nitric acid and carbonate of am-

monia, and afterwards distilling sulphuric acid from it, I procured from it sulphate of soda, which proves that it was a frit made by means of soda, and coloured with oxide of copper.

The undiluted colour in its form of frit is used for ornamenting some of the mouldings detached from the ceilings of the chambers in the baths of Titus: and the walls of one chamber between the compartments of red marble, bear proofs of having been covered with this frit, and retain a considerable quantity of it.

There is every reason to believe, that this is the colour described by THEOPHRASTUS as discovered by an Egyptian king;* and of which the manufactory is said to have been anciently established at Alexandria.

VITRUVIUS speaks of it, under the name of cæruleum,† as the colour used commonly in painting chambers, and states, that it was made in his time at Puzzuoli, where the method of fabricating it was brought from Egypt by VESTORIUS; he gives the method of preparing it by heating strongly together sand, flos nitri,‡ and filings of copper.

PLINY mentions other blues, which he calls species of sand (arenæ) from the mines of Egypt, Scythia, and Cyprus. These natural blues, there is reason to believe, were different preparations of lapis lazuli, and of the blue carbonates and arseniates of copper.

Both PLINY and VITRUVIUS speak of the Indian blue, which the first author states to be combustible, and which was evidently a species of indigo.

I have examined several blues in the fragments of fresco

* De Lapidibus, sect. xcviii. † Lib. vii. Cap. 11.

‡ This identifies the nitrum of the ancients with carbonate of soda.

painting from the ruins near the monument of CAIUS CESTIUS. In a deep blue approaching in tint to indigo, I found a little carbonate of copper, but the basis of this colour was the frit before described.

The blues in the Nozze Aldobrandine, from their resisting the action of acids, and from the effects of fire, I am inclined to consider as composed of the Alexandrian or Puzzuoli blue.

In an excavation made at Pompeii, in May 1814, at which I was present, a small pot containing a pale blue colour was dug up, which the exalted personage, by whose command the excavation was made, was so good as to put into my hands. It proved to be a mixture of carbonate of lime with the Alexandrian frit.*

VITRUVIUS states, that the ancients had a mode of imitating the Indian blue or indigo, by mixing the powder of the glass called by the Greeks ὕαλος, with selinusian "creta" or annularian "creta", which was white clay or chalk mixed with stained glass; the same practice is likewise referred to by PLINY.

There is much reason for supposing that this stained glass, or ὕαλος, was tinged with oxide of cobalt; and that these colours were similar to our smalt. I have not found any powdered colour of this kind in the baths of Titus, or in any other Roman ruins; but a blue glass tinged with cobalt is very common in those ruins, which when powdered forms a pale smalt.

I have examined many pastes and glasses that contain oxide of copper; they are all bluish green, green, or of an opaque watery blue. The transparent blue glass vessels which are

* This probably is the same colour as that examined by M. CHAPTAL. He did not search in it for alkali, or there is every reason to suppose he would have found soda.

found with the vases in the tombs in Magna Græcia are tinged with cobalt, and on analyzing different ancient transparent blue glasses which Mr. MILLINGEN was so good as to give me, I found cobalt in all of them.*

THEOPHRASTUS, in speaking of the manufacture of glass, states as a report that "χαλκὸς" was used to give it a fine colour, and it is extremely probable, that the Greeks took cobalt for a species of χαλκὸς. I have examined some Egyptian pastes which are all tinged blue and green with copper, but though I have made experiments on nine different specimens of ancient Greek and Roman *transparent* blue glass, I have not found copper in any, but cobalt in all of them.†

V. *Of the ancient greens.*

The ceiling of the chambers called the Baths of Livia is highly ornamented with gilding and paintings; the larger paintings have been removed, but the ground work and the borders remain. A fragment detached from the borders, which appears of the same colour as the ground work, was of a deep sea green. The colouring matter examined, proved to be soluble in acids with effervescence, and when precipitated from acids, it redissolved in solution of ammonia, giving it the

* The mere fusion of these glasses with alkali and digestion of the product with muriatic acid was sufficient to produce a sympathetic ink from them; even the silica separated by the acid gained a faint blue green tint by heat, and the solution in muriatic acid became pamanently green by the action of sulphuric acid, a phenomenon Dr. MARCET has observed as belonging to the muriate of cobalt.

† A gentleman at Milan informed me last summer that he had found oxide of cobalt in the blue glass found in the ruins of Hadrian's villa, and at this time I had no idea that cobalt was known to the ancients. Mr. HATCHETT, and Mr. KLAPROTH had both found oxide of copper in some ancient blue glasses, which I conceive must have been opaque.

bright blue tint produced by oxide of copper. There are several different shades of green employed in the baths of Titus, and on the fragments found near the monument of CAIUS CESTIUS: in the vase of mixed colours I found three different varieties; one, which approached to olive, was the common green earth of Verona; another, which was pale grass green, had the character of carbonate of copper mixed with chalk; and a third, which was sea green, was a green combination of copper mixed with the blue copper frit.

All the greens that I examined on the walls of the baths of Titus were combinations of copper. From the extreme brilliancy of a green which I found in the vineyard to which I have so often referred, I suspected that it might contain arsenious acid, and be analogous to SCHEELE'S green; but on submitting it to experiments, it afforded no indications of this substance, and proved to be a pure carbonate of copper.

The greens of copper were well known to the Greeks; the most esteemed is described by THEOPHRASTUS and DIOSCORIDES under the name of χρυσοκόλλα, and is stated by both to be found in metallic veins.

VITRUVIUS mentions chrysocolla as a native substance found in copper mines, and PLINY speaks of an artificial chrysocolla made from the clay found in the neighbourhood of metallic veins, which clay was most probably impregnated with copper. He describes it as rendered green by the herb luteum. There is every reason to believe, that the native chrysocolla was carbonate of copper, and that the artificial was clay impregnated with sulphate of copper rendered green by a yellow die.

Some commentators have supposed that chrysocolla is the

same substance as borax, because PLINY has mentioned that a preparation called by this name was used by goldsmiths for soldering gold;* but nothing can be more gross than this mistake, which, however, has been copied into many elementary books of chemistry. The material used for soldering gold consisted of carbonate or oxide of copper mixed with alkaline phosphates. This is evident from the description of DIOSCORIDES " Περὶ ιοῦ σκώληκος Lib. v. c. 92, who says it was prepared from urine treated in brass mortars. PLINY says likewise, that it was prepared from " Cypria ærugine et pueri impubis urina, addito nitro."† The name of chrysocolla was probably derived from the green powder used by the goldsmiths, and which contained carbonate of copper as one of its ingredients.‡

Amongst the substances found in the baths of Titus were some masses of a grass green colour. I at first thought these might be specimens of native chrysocolla; they proved indeed to be carbonate of copper, but it had formed round longitudinal nuclei of red oxide of copper, so that probably these substances had been copper nails or small pieces of copper used in the building, converted by the action of the air, during so many centuries, into oxide and carbonate.

The ancients, as it appears from THEOPHRASTUS, were well

* Hist. de la Peinture ancienne, pag. 38. " Nos droguistes la nomme Borax."

† Lib. xxxiii. Cap. 5.

‡ The commentators have been likewise misled by PLINY's description, " chrysocolla humor est in puteis per venam auri defluens, &c." Ibid; but this is merely an inaccurate account of the decomposition of a vein containing copper. We have no reason for supposing that the Greeks and Romans were acquainted with borax. PLINY, probably misled by the application of the same name to different substances, considered chrysocolla as the cement of gold in mineral veins.

acquainted with verdigrise. VITRUVIUS mentions it amongst pigments, and probably many of the ancient greens, which are now carbonate of copper, were originally laid on in the state of acetite.

The ancients had beautiful deep green glasses, which I find are tinged with oxide of copper; but it does not appear that they used these glasses in a state of powder as pigments.

The greens of the Aldobrandini picture are all of copper, as was evident from the action of the muriatic acid upon them.

VI. *Of the purple of the Ancients.*

The Πορφύρα of the Greeks, and the ostrum of the Romans, was regarded as their most beautiful colour, and was prepared from shell fish.

VITRUVIUS * says, that the colour differed according to the country from which the shell fish was brought; that it afforded a colour deeper and more approaching to violet from the northern countries, and a redder colour from the southern coasts. He states, that it was prepared by beating the fish with instruments of iron, freeing the purple liquor from the shell containing it, and mixing it with a little honey: and PLINY says, that for the use of the painters argentine "creta" † was dyed with it: and both VITRUVIUS and PLINY say, that it was adulterated, or imitations of it made, by tinging "creta" with madder, ‡ and "hysginum." The finest purple, PLINY

* Lib. vii. Cap. 13.

† Probably a clay used for polishing silver. The ancients were not acquainted with the distinction between aluminous and calcareous earths, and *creta* was a term applied to every white fine earthy powder.

‡ Madder was extensively used by the ancients in dying, and from this passage it is probable, that they were acquainted with the art of making a lake from it similar

says, had a tint like that of a deep coloured rose: and in painting, he states that it was laid on to give the last lustre to the sandyx, a composition made by calcining together red ochre and sandarach, and which therefore must have been nearly the same as our crimson.

In the baths of Titus there is a broken vase of earthen ware, which contains a pale rose colour; where it has been exposed to air, it has lost its tint, and is become of a cream colour, but the interior has a lustre approaching to that of carmine.

I have made many experiments on this colour. It is destroyed and becomes of a red brown by the action of concentrated acids and alkalies; but diluted acids dissolve a considerable quantity of carbonate of lime with which the body colour is mixed, and leave a substance of a bright rose colour: this substance when heated first blackens, and when urged with a strong flame becomes white; and treated with alkali, proves to be composed of siliceous, aluminous, and calcareous earths, with no sensible quantity of any metallic substance, except oxide of iron.

I endeavoured to discover if the colouring matter was combustible. It was gradually heated in a glass tube filled with oxygene; it did not inflame but became red hot sooner than it would have done had it been merely earthy matter: on exposing the gas in the tube to lime water, there was a precipitation of carbonate of lime. Some of it was mixed with hyperoxymuriate of potassa, and heated in a small retort;

to that used by modern painters. It was probably one of the colours used by the Egyptians in dying their stuffs of different colours from the same liquor, by means of mordants. If we can trust PLINY's account, they practised calico printing in a manner similar to the moderns. Lib. xxxv. Cap. 42.

when the salt fused there was a slight scintillation, a little moisture appeared, and the gas given off received into lime water occasioned a very evident precipitation.

It appeared from these experiments, that the colouring matter was a compound of either vegetable or animal origin. I threw some of it upon a hot iron, it emitted scarcely any smoke, and gave a smell which had some resemblance to that of prussic acid, but which was extremely faint.

When hydrate of potassa was fused in contact with it, the vapours that rose had no distinct ammoniacal smell; they gave indeed slight fumes to paper moistened with muriatic acid, but this is far from being an unequivocal proof of animal matter. I compared this colour with vegetable lake from madder, and animal lake from cochineal diluted to the same degree as nearly as could be judged, and fixed upon clays. The lake of madder, after being dissolved in strong muriatic acid, had its colour restored by alkalies, which was not the case with the ancient lake. The lake of madder likewise gave a much deeper tint to muriatic acid, and produced a tawny hue when its weak muriatic solution was acted on by muriate of iron; whereas the ancient lake did not change in colour. The ancient lake agreed with the lake of cochineal in being rendered of a deeper hue by weak alkalies, and of a brighter hue by weak acids; but it differed from it in being much more easily destroyed by strong acids. It agreed with both the vegetable and animal lakes in being immediately destroyed by a solution of chlorine.

The lake made from cochineal produced much denser fumes when exposed to fused potash, and afforded a distinct ammoniacal smell. The two modern lakes when burnt in oxygene

did not give stronger signs of inflammation than the ancient. I ascertained the loss of weight this ancient lake suffered by combustion, and found it only $\frac{1}{30}$, and this loss must in great part have depended on the expulsion of water from the clay on which it was fixed. This circumstance induced me to renounce the idea of attempting to determine its nature from the products of its decomposition; which in the case of so small a quantity of matter diffused over so large a quantity of surface could not have afforded unequivocal results.

The durability of this lake, whether vegetable or animal, is a very curious circumstance; but the exterior part which has been exposed to air has suffered.—This durability probably depends in a great measure upon the attractive powers of so large a mass of alumina; for whenever one proportion of a substance is combined with many proportions of another substance, it is very difficult to decompose or detach the one proportion.

From the circumstances which have been noticed respecting this colour, it is impossible to form an opinion whether it is of vegetable or animal origin. If of animal origin, it is most probably the Tyrian or marine purple: and by some comparative experiments on the purple obtained from shell fish the question might perhaps be decided.* It is very probable that the most expensive colour would be employed for orna-

* M. Chaptal considers the lake he found amongst the colours from Pompeii (as I have already mentioned) as of vegetable origin; and he founds his opinion upon the circumstance of its not affording by decomposition the smell peculiar to animal substances: but probably this smell, even if produced by recent purple colouring matter of animal origin, would not belong to colouring matter of 1700 years old. For it is most probably owing merely to albumen or gelatine not essential to the colouring particles, and much more rapidly decomposed.

menting the imperial baths; and it is not impossible that PLINY may have alluded to the palace of the Cæsars when he says "nunc et purpuris in parietes migrantibus, et India conferente fluminum suorum limum, et draconum et elephantorum saniem, nulla nobilis pictura est." Lib. xxxv. Cap. 32.

I have seen no colour of the same tint as this ancient lake in any of the ancient paintings in fresco. The purplish reds in the baths of Titus are mixtures of red ochres and the blues of copper.—In the Aldobrandini picture there is a purple in the garment of the Pronuba, but of an inferior hue; and this purple appears to be a compound mineral colour of the nature of these.—It was not destroyed by solution of chlorine; and when a little of it was exposed to muriatic acid, it rendered the acid yellow, and the remainder yielded a residual blue powder.

VII. *Of the blacks and browns of the Ancients.*

There is one chamber in the baths of Titus of which the ground work is black. I have found several fragments of stucco painted black both in the baths of Titus and in the vineyard above mentioned, and also in some ruins near the Porta del Popolo.—I scraped off some of these colours and submitted them to experiments: they were not acted on by acids or alkalies, they deflagrated with nitre, and had all the properties of pure carbonaceous matter.

I found no blacks, but three different shades of brown in the vase of mixed colours; one was snuff colour, one deep red brown, and the third a dark olive brown. The two first proved to be ochres which had been probably partially calcined; the third contained oxide of manganese, as well as

oxide of iron, and afforded chlorine when acted on by muriatic acid.

All the ancient authors describe the artificial Greek and Roman blacks as carbonaceous, and made either from the powder of charcoal or the decomposition of resin, (a species of lamp black) or from the lees of wine, or from the common soot of wood fires. PLINY mentions the inks of the cuttle fish, but says, "ex his non fit."* Some years ago I examined this substance, and found it a carbonaceous body mixed with gelatine. PLINY speaks of ivory black as invented by Apelles; he says likewise that there is a natural fossil black, and another black prepared from an earth of the colour of sulphur. Probably both these substances are ores of iron and manganese.

That the ancients were acquainted with the ores of manganese is evident from the use made of it in colouring glass. I have examined two specimens of ancient Roman purple glass, both of which were tinged with oxide of manganese.—PLINY speaks of different brown ochres, and particularly of one from Africa, which he names Cicerculum, which probably contained manganese: and THEOPHRASTUS mentions a fossil† which inflamed when oil was poured upon it, a property belonging to no other fossil substance now known but the *black wad*, an ore of manganese, and which is now found in Derbyshire.

The browns in the paintings in the baths of Livia, and in the Aldobrandini picture, are all produced by mixtures of ochres

* i e. the atramentum.

† THEOPHRASTUS says it is like decomposed wood παρόμοιος ὧν ξύλῳ σαπρῷ, 12th page of John de Laet's edition.

with blacks. Those in the Aldobrandini picture yield oxide of iron to muriatic acid, but the darker shades were not touched by that acid, nor by solution of alkalies.

VIII. *Of the whites of the Ancients.*

The white colours in the Aldobrandini picture are soluble in acids with effervescence, and have the characters of carbonate of lime.

The principal white in the vase of mixed colours appears to be a very fine chalk. There is another white with a tint of cream colour, which is a fine aluminous clay.

The whites that I have examined from the baths of Titus, and those from other ruins, are all of the same kind.

I have not met with ceruse amongst the ancient colours, though we know from THEOPHRASTUS, VITRUVIUS, and PLINY, that it was a common colour: and VITRUVIUS describes it as made by the action of lead upon vinegar.

Several white clays are mentioned by PLINY as employed in painting, of which the Parætonium was considered as affording the finest colour.

IX. *Of the manner in which the Ancients applied their colours.*

It appears from VITRUVIUS that the colours used in fresco painting were applied moist to the surface of a stucco* formed of powdered marble cemented by lime; he states that the wall or ceiling had three distinct coatings of stucco made of this material, of which the first contained coarse powder of marble, the second the finer powder, and the third the finest

* Lib. vii. Cap. 2, 3, and 4.

powder of all, and that after this the wall was polished before the colour was applied. The stuccos that remain in the ruins of the baths of Titus and Livia are of this kind, and so is the ground of the Aldobrandini picture; they are beautifully white, and almost as hard as marble, and the granular marble of different degrees of fineness may be distinguished in them. This circumstance indeed offers a test of the antiquity of ruins at Rome. In the houses that have been built in the middle and later ages, decomposing lava has been mixed with the calcareous cement instead of granular marble, and the stuccos of these houses are grey or brown, and very coarse in their texture.

PLINY says that purple, orpiment, ceruse, the natural azure, indigo, and the meline white, were injured by application to wet stucco, which is easily explained in the case of orpiment, carbonate of copper, ceruse, and indigo, from their chemical composition.

VITRUVIUS states that in fresco painting vermilion changed if exposed to light, and he recommends the encaustic process for fixing the colour under this circumstance, namely, laying over it a coat of punic wax, and liquifying the wax so as to make a varnish for the colour.

PLINY describes this process as applied in painting ships; and we know from his authority that several pictures of the great Greek masters were painted in encaustic, and that the different colours were laid on mixed with wax. I have examined several pieces of the painted stuccos found in the different ruins, and likewise the Aldobrandini picture, with a view of ascertaining if any application had been made to fix the colour; but neither by the test of alcohol, nor by heat,

nor by the action of water, could I detect the presence of any wax varnish, or animal or vegetable gluten.

The pot of colours to which I have already referred, found at Pompeii, was blackened by smoke, as if it had been recently on a fire of wood. I thought that this might be owing to some process for dissolving gluten or varnish in the preparation of the colour; but I could detect no substance of this kind mixed with the colouring matter.

PLINY states, that gluten (our glue)* was used in painting with blacks: and this specific mention of its application would induce the belief that it was not employed with other colours, which adhered without difficulty to, and were imbibed by, a surface so polished and well prepared as the Roman stucco; and the lightness of carbonaceous matter alone probably rendered this application necessary.

X. *Some general observations.*

It appears from the facts that have been stated, and the authorities quoted, that the Greek and Roman painters had almost all the same colours as those employed by the great Italian masters at the period of the revival of the arts in Italy. They had indeed the advantage over them in two colours, the Vestorian or Egyptian azure, and the Tyrian or marine purple.

The azure, of which the excellence is proved by its duration for seventeen hundred years, may be easily and cheaply made; I find that fifteen parts by weight of carbonate of soda, twenty parts of powdered opaque flints, and three parts of copper filings strongly heated together for two hours, gave a

* Lib. xxxv. Cap. 25. "Omne atramentum sole perficitur, librarium gummi tectorium glutino admixto."

substance of exactly the same tint, and of nearly the same degree of fusibility, and which, when powdered, produced a fine deep sky blue.

The azure, the red and yellow ochres, and the blacks are the colours that seem not to have changed at all, in the ancient fresco paintings. The vermilion is darker than recently made Dutch cinnabar, and the red lead is inferior in tint to that sold in the shops. The greens in general are dull.

The principle of the composition of the Alexandrian frit is perfect; namely, that of embodying the colour in a composition resembling stone, so as to prevent the escape of elastic matter from it, or the decomposing action of the elements; this is a species of artificial lapis lazuli, the colouring matter of which is naturally inherent in a hard siliceous stone.

It is probable that other coloured frits may be made, and it is worth trying whether the beautiful purple given by oxide of gold, cannot be made useful in painting in a densely tinted glass.

Where frits cannot be employed, metallic combinations which are insoluble in water, and which are saturated with oxygene or some acid matter, it is evident from the proof of a duration of seventeen centuries, are the best pigments. In the red ochres the oxide of iron is fully combined with oxygene, and in the yellow ochres it is combined with oxygene and carbonic acid; and these colours have not changed. The carbonates of copper which contain an oxide and an acid have changed very little.

Massicot and orpiment were probably the least permanent amongst the ancient mineral colours.

Of the colours, the discovery of which is owing to the im-

provements in modern chemistry, the patent yellow is much more durable than any ancient yellow of the same brilliancy; and chromate of lead, an insoluble compound of a metallic acid with a metallic oxide, is a much more beautiful yellow than any possessed by the ancients, and, there is every reason to believe, is quite unalterable.

SCHEELE'S green (the arsenite of copper), and the insoluble muriatic combination of copper, will probably be found more unalterable than the ancient greens; and the sulphate of baryta offers a white superior to any possessed by the Greeks and Romans.

I have tried the effect of light and air upon some of the colours formed by the new substance iodine. Its combination with mercury offers a good red, but it is, I think, less beautiful than vermilion, and it appears to change more by the action of light.

Its compound with lead gives a beautiful yellow, little inferior to the chromate of lead; and I possess some of this colour which has been exposed to light and air without alteration for several months.

In many of the figures and ornaments in the outer chambers of the baths of Titus, where only outlines or spots remain, or shades of ochre, it is probable that vegetable or animal colours, such as indigo and the different dyed clays, were used.*

PLINY speaks of the celebrated Greek painters as employing only four colours. "Quatuor coloribus solis immortalia illa opera fecere: ex albis Melino, ex silaceis Attico, ex rubris

* Some excellent pictures have suffered very much in modern times from the same cause; the lakes in the frescos of the Vatican have lost much of the brilliancy which they must have possessed originally. The blues in many pictures of Paul Veronese are become muddy.

Sinopide Pontica, ex nigris atramento, Apelles, Echion, Melanthius, Nicomachus, clarissimi pictores;"* but as far as Apelles and Nicomachus are concerned, this is a mistake: and it is not unlikely that PLINY was misled by an imperfect recollection of a passage in CICERO, who describes the earlier Greek school as using only four colours; but the later Greek painters as perfect masters in all the resources of colouring. "Similis in pictura ratio est: in qua Zeuxim, et Polygnotum, et Timantem, et eorum, qui non sunt usi plus quam quatuor coloribus, formas et lineamenta laudamus: at in Aetione, Nicomacho, Protogene, Apelle, jam perfecta sunt omnia." CICERO, Brutus, seu de claris oratoribus, c. 18. PLINY himself describes with enthusiasm the Venus ἀναδυομένη of Apelles: and in this picture the sea was represented, which required azure.

The great Greek painters, like the most illustrious artists of the Roman and Venetian school, were probably, however, sparing in the use of the more florid tints in historical and moral painting, and produced their effects rather by the contrasts of colouring in those parts of the picture where a deep and uniform tint might be used, than by brilliant drapery.

If red and yellow ochres, blacks and whites, were the colours most employed by Protogenes and Apelles, so they are likewise the colours most employed by RAPHAEL and TITIAN in their best style. The St. John and the Venus, in the tribune of the Gallery at Florence, offer striking examples of pictures in which all the deeper tints are evidently produced by red and yellow ochres, and carbonaceous substances.

As far as colours are concerned, these works are prepared for that immortality which they deserve; but unfortunately

* Lib. xxxv. c. 32.

the oil and the canvas are vegetable materials, and liable to decomposition, and the last is less durable than even the wood on which the Greek artists painted their celebrated pictures.

It is unfortunate that the materials for receiving those works which are worthy of passing down to posterity as eternal monuments of genius, taste, and industry, are not imperishable marble* or stone: and that frits, or unalterable metallic combinations, have not been the only pigments employed by great artists; and that their varnishes have not been sought for amongst the transparent combinations of the earths with water, or amongst the crystalline transparent compounds unalterable in the atmosphere.†

* Copper, it is evident, from the specimens in the ruins of Pompeii, is a very perishable material, and, therefore, even enamels made on copper will yield to time. Canvas, by being impregnated with bitumen, is rendered much more durable, as is evident from the duration of the linen impregnated with bitumen and asphaltum used for infolding the Egyptian mummies.

† The artificial hydrat of alumina will probably be found to be a substance of this kind: possibly the solution of boracic acid in alcohol will form a varnish.—The solution of sulphur in alcohol is likewise worthy of an experiment. Many other similar combinations might be named.

Rome, January 14th, 1815.